Claims

1. A seismic isolator for a structure supported on a mounting surface, the structure including a base having an inner surface facing the mounting surface and an outer surface opposite the inner surface, comprising:

a load shaft having opposing first and second ends, the first end adapted to be secured to the mounting surface, and the load shaft sized so that the second end of the load shaft extends beyond the outer surface of the base of the structure;

an actuator having a mounting end adapted to be secured to the base and a driver spaced apart from the mounting end; and

a resilient element operably interposed between the driver and the second end of the load shaft to allow relative motion between the mounting surface and the structure in the event of a seismic shock or other external applied force and to absorb or dissipate energy of such relative motion, thereby attenuating the effect on the structure of the seismic shock or other external applied force.

2. A seismic isolator according to claim 1 wherein the resilient element includes a friction spring.

3. A seismic isolator according to claim 1 wherein the actuator includes a tubular actuator stem into which the load shaft extends.

4. A seismic isolator according to claim 1 wherein the resilient element resists relative motion in a first direction, and further comprising a secondary resilient element operably interposed between the driver and the mounting surface to resist relative motion in a second direction opposite the first direction.

5. A seismic isolator according to claim 4 wherein the secondary resilient element includes a second friction spring.

6. A seismic isolator according to claim 4 wherein the load shaft includes a radially extending shoulder located proximal of the first end for supporting the secondary resilient element opposite the driver.

7. A seismic isolator according to claim 4 wherein the actuator or the load shaft, or both, are adjustable for selectively applying a preload to the secondary resilient element.

8. A seismic isolator according to claim 1 wherein the structure supports an item of equipment in an electric power system.

9. A seismic isolator according to claim 1 wherein no part of the seismic isolator extends below the base of the structure.

10. A seismic isolator according to claim 1 wherein the load shaft is secured to the mounting surface via a threaded mounting stud that extends outwardly from the mounting surface and through the base of the structure.

11. A seismic isolator according to claim 1, further comprising a cap secured to the second end of the load shaft to retain the resilient element.

12. A seismic isolator according to claim 11 wherein the cap is adjustably secured to the load shaft for positioning therealong to selectively apply a preload to the resilient element.

13. An apparatus for protecting a structure from seismic shock or other external applied force, comprising

a load shaft having opposing first and second ends, the first end adapted to be secured to a mounting surface on which a base of the structure is supported, such that the second end of the load shaft projects beyond the base;

an actuator extending along the load shaft, the actuator having opposing mounting and driving ends, the mounting end located proximal of the first end of the load shaft and adapted to be supported on the structure, and the driving end extending toward the second end of the load shaft; and

a resilient element operably interposed between the driving end of the actuator and the second end of the load shaft to allow relative motion between the mounting surface and the structure in the event of a seismic shock or other external applied force, and to absorb or dissipate energy of such motion.

14. An apparatus according to claim 13 wherein:

the resilient element includes a primary annular friction spring assembly;

the load shaft comprises an elongate member that extends axially through the friction spring assembly; and

the actuator includes a tubular member surrounding at least a section of the load shaft.

15. An apparatus according to claim 14 wherein the primary annular friction spring assembly resists relative motion in a first direction, and further comprising a secondary annular friction spring assembly supported on the load shaft between the driving end of the actuator and the mounting surface to resist relative motion in a second direction opposite the first direction.

16. An apparatus according to claim 13 wherein the mounting end of the actuator is securely attached to the structure.

17. An apparatus according to claim 13 wherein the resilient element resists relative motion in a first direction, and further comprising a secondary resilient element operably interposed between the driving end of the actuator and the mounting surface to resist relative motion in a second direction opposite the first direction.

18. An apparatus according to claim 17 wherein the load shaft includes a radially extending shoulder located proximal of the first end for supporting the secondary resilient element opposite the driving end of the actuator.

19. An apparatus according to claim 17 wherein the actuator includes an annular driver supported proximal of the driving end of the actuator for transmitting force from the base of the structure to the primary and secondary resilient elements.

20. An apparatus according to claim 19 wherein the driver is detachable from the actuator for facilitating servicing of the apparatus after installation.

21. An apparatus according to claim 16 wherein the structure supports an item of equipment in an electric power system.

22. An apparatus according to claim 13 wherein the load shaft is secured to the mounting surface via a threaded mounting stud that extends outwardly from the mounting surface and through the base of the structure, such that no part of the apparatus extends below the base of the structure.

23. A seismic retrofitting method for an existing structure of the type including a base supported on a mounting surface and secured to the mounting surface via a threaded mounting stud that extends from the mounting surface through a hole or slot in the base and a nut threaded onto the mounting stud over the base, comprising:

providing a seismic isolator including a load shaft, an actuator aligned with the load shaft, and a resilient element operably interposed between the load shaft and the actuator to allow relative motion therebetween and to resist such motion;

loosening or removing the nut from the mounting stud;

without moving the structure, attaching the load shaft onto the mounting stud and positioning the actuator over the base, the seismic isolator thereby allowing limited relative motion between the mounting surface and the structure in the event of a seismic shock or other external applied force, and absorbing or dissipating energy of such motion.

24. A seismic retrofitting method according to claim 23, further comprising attaching the actuator to the base of the structure.

25. A seismic retrofitting method according to claim 23, further comprising preloading the resilient element.

26. A seismic retrofitting method according to claim 23 wherein:

the resilient element includes a primary resilient element and a secondary resilient element; and

the step of operably interposing the resilient element includes:

installing the secondary resilient element on the load shaft,

securing the actuator to the structure,

after installing the secondary resilient element, installing the primary resilient element on the load shaft over the actuator and the secondary resilient element, and

installing a cap onto the load shaft over the primary resilient element to retain the primary and secondary resilient elements on the load shaft.

27. A seismic retrofitting method according to claim 26, further comprising preloading the secondary resilient element.

28. A seismic retrofitting method according to claim 23 wherein the load shaft is threadably attached to the mounting stud.

29. A seismic retrofitting method according to claim 23, further comprising attaching the actuator to the base with a threaded fastener.

30. A seismic retrofitting method according to claim 23, further comprising welding the actuator to the base.